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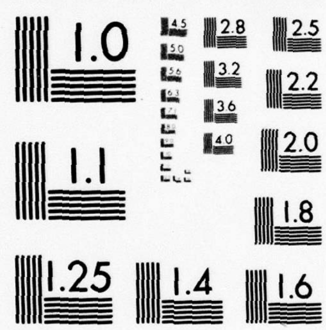

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FIELD STUDY OF STRESS: PSYCHOPHYSIOLOGICAL MEASURES DURING PROJECT SUPEX.

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This study, conducted in collaboration with the Combat Developments Experimentation Command (CDEC) in a planned project entitled SUPEX, evaluated psychophysiological recording techniques in a stressful field situation. Continuous recordings of heart rate and general muscle tension were compared with performance suppression measures obtained by CDEC. Selected test scales of perceived anxiety/stress were administered to the participants. These data were compared with both the performance and the psychophysiological measures. (Cont)

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Changes in heart rate were sensitive indicators both of anticipation and response to weapon fire. Both the rate of weapon fire and size of direct fire weapons directly influenced heart rate while indirect fire weapon affected heart rate only marginally. Several parameters of heart rate correlated significantly with performance measures. General muscle tension recordings proved to be unreliable utilizing the current procedures. The perceived scales evaluated the current state of the individual, but they were not good predictors of performance or heart rate activity.

ABSTRACT

This study, conducted in collaboration with the Combat Developments Experimentation Command (CDEC) in a planned project entitled SUPEX, evaluated psychophysiological recording techniques in a stress-field situation. Continuous recordings of heart rate and general muscle tension were compared with performance suppression measures obtained by CDEC. Selected test scales of perceived anxiety/stress were administered to the participants. These data were compared with both the performance and the psychophysiological measures.

Changes in heart rate were sensitive indicators both of anticipation and response to weapon fire. Both the rate of weapon fire and size of direct fire weapons directly influenced heart rate while indirect fire weapon affected heart rate only marginally. Several parameters of heart rate correlated significantly with performance measures. General muscle tension recordings proved to be unreliable utilizing the current procedures. The perceived scales evaluated the current state of the individual, but they were not good predictors of performance or heart rate activity.

PREFACE

The authors wish to express their appreciation to Mr. Victor J. Pribyl, Mr. David A. Stamper, and Mr. Robert A. Patterson for their technical assistance and their support in the data collection and analysis phase of this study.

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INTRODUCTION

Various psychophysiological measures, such as heart rate, blood pressure, electromyographic activity or muscle tension, and galvanic skin response, have been used to study stress both in the laboratory and in the field (1-5). Such measures offer distinct advantages over the more standard biochemical analyses of stress. Psychophysiological indices do not involve "invasive" procedures (e.g., obtaining a blood sample), as do many of the biochemical techniques. They are continually accessible and do not involve an appreciable lag between event and response, thus continuous monitoring capability is afforded. This makes it possible to assess an individual's responses to discrete short-lived events such as intermittent weapons fire.

Measures of heart rate and muscle electrical activity were selected for study. Anticipatory phasic accelerative and decelerative heart rate changes occur when subjects are provided with advance information concerning the onset of the task. Increases in heart rate during the preparatory interval may reflect cardiovascular and somatic adjustments to anticipated metabolic requirements (6). The transient cardiac deceleration which may occur immediately before task execution is thought to be related to attentional processes (7-9). Both patterns of phasic heart rate change have been related to speed and accuracy of task execution. Indices of electromyographic activity have also been related to performance efficiency (10-12). Recordings of electrical activity from muscle groups not involved in task requirements have been used as sources of information concerning general "arousal" or "activation" (13). Recording sites on neck, chin, and over the frontalis muscle have often been used for this purpose.

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This study was performed as a collaborative effort with the Combat Developments Experimentation Command (CDEC) to apply psychophysiological recording techniques in a stressful field situation. The major emphasis was directed toward examing the interaction of stress and performance variables. The primary objectives of the study were:

(a) To determine the sensitivity of heart rate and general muscle tension to weapons fire.

(b) To evaluate potential relationships between psychophysiological measures and suppression of performance due to weapons fire effects.

(c) To evaluate possible realtionships between selected scales of perceived anxiety/stress and performance suppression and psychophysiological measures.

PHASE I - DIRECT FIRE WEAPONS

Subjects

Subjects, referred to as "players," were eleven enlisted men of the experimentation unit attached to CDEC. Although medical records were not examined it is assumed that the players were normal and in good health. All subjects were briefed on the nature of the study, including possible adverse effects. Following the briefing, each volunteer read and signed a volunteer consent agreement (Appendix A).

Materials and Apparatus

The direct-fire weapons used were the M-60 machine gun (7.62 mm), the M-139 (20 mm cannon, track mounted, high explosive round), and the MK-19 (grenade launcher with 40 mm high explosive round). Other smaller weapons had been used in a week of preliminary sessions. Three rates of fire were used with the M-139 and Mk-19: low (two rounds per burst, 4-5 sec inter-burst interval), medium (five rounds per burst, 3-4 sec inter-burst interval) and high (eight rounds per burst, 1-2 sec inter-burst interval). Intra-burst firing rate was approximately two per second for the medium and high rates of fire, while it was about one per second for the low rate.

Facing the firing line at a distance of 450 m were four bunkers set into a slope such that the tops were level with the ground extending from the bunker fronts to the firing line. Each bunker was constructed of wood, steel plate, and steel mesh and was protected on the outside by earth and sandbags. A periscope extended vertically through the roof and could be "lowered" by sliding a metal plate downward over the lower opening. The fixed up-range viewing field was the same for all four periscopes. In front of the bunker and in the field of the periscope was a "pop-up" target which went up and down with the raising and lowering of the periscope. The target was rigged to fall back when hit by a round or flying rock. Slightly in front of and approximately 5 m to the right of each bunker was an aiming stake, at which

the weapons were aimed when firing was in progress.

Up range at a distance of approximately 1500 m was a row of bill-board-size panels numbered 0 through 12. This row of panels extended across the entire width of each periscopes's field of view and served as reference points for tracking tanks driving along the row of panels.

Protective gear worn by each player included a flak vest and steel helmet.

For recording psychophysiological measures, small four-channel tape recorders (Medilog 4-24) were strapped on the players. Three miniature silver-silver chloride electrodes (Beckman) were used for recording the electromyogram (muscle tension), two over the left masseter muscle and one on the left ear lobe as a ground. Two stress test electrodes (American Hospital Supply) were attached to the chest for the electrocardiogram. A small microphone was used to record low-frequency sounds on a third channel of the recorder. This information was later used to identify trials.

Three paper-and-pencil scales were used to assess subjective state. These were the Trait Anxiety Inventory (14) a shortened version fo the State Anxiety Inventory (14) and the Subjective Stress Scale (15).

Method

The same weapon and rate of fire were used within a given trial. The impact area, although only 5 m or so from the bunker, was not directly in the player's field of view. While the 40 mm round fired from the MK-19 raised considerable dust upon exploding, the 20 mm round from the M-139 raised little dust. Thus, visibility of impacting rounds depended primarily on the size of the round plus the wind direction and speed. Each individual bunker received four bursts per trial, which yielded a total of 16 bursts impacting at the bunker line during each trial. The order in which the bunkers received the bursts varied randomly. The total length of a trial ranged from 56 to 128 sec, with an average length of 77 sec.

The basic task performed by the players was a target tracking task in a game playing context. Observing through the periscope the row of numbered panels up-range, the player called off the number of each panel as the target tank passed it. An uninterrupted track of 15 sec or longer, with numbers called matching those called off by the tank crew, produced a score of one "kill." The players were to imagine they were guiding an anti-tank missile which required continuous guidance. The pop-up target in front of the bunker went down automatically when hit by a round or flying fragment. The players were instructed to attempt to minimize the risk of a hit to the pop-up target. This they did by lowering the periscope, simultaneously lowering the target, whenever they judged it necessary. A "hit" taken by the upright target produced a loud tone in the bunker

14. Spielberger, et al, STAI Manual, 1970
15. Berkun, N.M., et al, Psychol Monogr 76(15, No. 534), 1962

and reset the 15-sec "kill" clock to zero. The player was then forced to "lower" the periscope until he judged it safe to raise it again, at which time the "kill" clock resumed running. A "hit" on the pop-up target cost the player an unspecified number of points to be determined later by a weighting procedure. A tank kill was signalled to the player by a light appearing in the periscope's field of view. The maximum number of tank "kills" possible depended on the length of the trial but was rarely less than four. Thus, the rules of the game called for optimizing the final score by maximizing the number of tank kills while minimizing the number of hits taken by the pop-up target. The tendency to lower the periscope voluntarily while receiving weapons fire was referred to as "suppression." Quantitative performance was measured by the number of tank kills, the percent of total trial time spent with the periscope up (non-suppressed), and the number of hits to the pop-up target. The teams of players were in competition for a three-day pass plus, presumably, a certain amount of personal satisfaction.

For each of the teams, trials occurred in blocks of four or five. Sessions were run in the afternoon and lasted from 20 min to one hr, excluding preparation time. The time between trials varied between 5 and 45 min, with an average of 12 min. Each trial was preceded by approximately 60 sec with a warning to the players that the trial was about to begin. Players were seated at the periscope during each trial; they remained inside the bunker between trials but they were free to stand and move about.

The paper-and-pencil scales were administered during the preparatory phase prior to the start of a session. The three scales required approximately 10 min for each player to complete. In addition, on selected occasions, the Subjective Stress Scale and the State Anxiety Inventory were administered upon completion of a session to assess subjective reactions during selected trials.

Data Analysis

During the three days of data collection, one player completed two separate sessions; data from his second session were discarded; thus nonrepetitive data from a total of 11 players remained for analysis. Individual players were members of groups which received somewhat different schedules of trials (Appendix B) and the total number of players run under each condition varied. This yielded an unbalanced "design" of neither independent groups nor repeated measures type. Because of the statistical problems posed by this state of affairs, and because of apparent cases of heterogeneity of variance, nonparametric statistics were chosen for all data analyses. Because of limitations of even the more sophisticated nonparametric tests (there is no nonparametric analogue of the multi-factor analysis of variance), all data sets were analyzed one factor at a time. The statistical tests used included the sign test, the Wilcoxon signed-ranks test, the Mann-Whitney U-test, the Friedman "two-way analysis of vari-

ance," and the Kruskal-Wallis one-way "analysis of variance" (16).

While three weapons were used on the first day, only one trial was given with the M-60. Since the players on the following two days received no M-60 trials, only data for the M-139 and MK-19 were subjected to statistical analysis.

Because of excessive movement artifacts in the electromyographic signals, no attempt has been made to analyze these data. The electrocardiographic signals were transferred from magnetic tape to an oscillograph, yielding strip-chart visual displays. Sample displays are presented in Appendix C. Heart rate measures were obtained from these displays by counting the number of R-waves in a 6-sec period and multiplying by 10 to yield a measure expressed in beats per minute. A 12 sec period was generally used to obtain baseline heart rate measures. The lowest 12-sec value during at least a 5-min period of quiet sitting was taken as an estimate of each individual's resting baseline heart rate.

Four primary heart rate parameters were derived from the raw heart rate data. In order to equate for systematic differences in absolute heart rate levels, "normalized" scores were derived by dividing the raw heart rate measures by either the individual's resting baseline value or his "running baseline" (determined prior to each trial). Four aspects of heart rate activity were quantified: two pre-trial measures, one measure of peak activity during the trial, and one post-trial measure. <u>Relative pre-trial level</u> (RPreTL) was determined by dividing the heart rate 60 to 90 sec before the start of a trial (PreTB) by the resting baseline rate. <u>Relative pre-trial acceleration</u> (RPreTA) was derived when it was noticed that most individuals showed an obvious pattern of transient heart rate acceleration 15-40 sec preceding a trial. The peak of this pattern was divided by the PreTB score to produce the RPreTA. This score may have represented a preparatory response as the player anticipated the start of the next trial. <u>Relative peak change</u> (RPkC) was computed by dividing the maximum 60 sec heart rate during the trial by the PreTB. <u>Relative post-trial level</u> (RPoTL) was computed by dividing the heart rate one minute after the end of the trial by the PreTB. All parameters were converted to percent change scores, and these were then subjected to statistical analysis.

Results and Discussion of Results

The over-all effect of a trial was an increase in heart rate. All four parameters showed significant increases (Appendix D, Fig 1), as evaluated by sign tests. Waiting in the bunker for the start of a trial elevated the players' heart rates (RPreTL) an average of 7% ($p<0.001$; Fig 1A). The proximate anticipation of the start of a trial was accompanied by significant RPreTA scores (transient acceleration) averaging 18% ($p<0.001$). Further increases in heart rate produced by the actual trial were reflected in significant RPkC scores averaging 21% ($p<0.001$; Fig 1B). Finally, significant positive RPoTL

16. Siegel, S., New York: McGraw-Hill, 1956

scores ($p<0.012$; Fig 1C) indicated heart rates were still elevated 1 minute after the end of the trial. For none of these four parameters was there any significant change across trials.

Both size of weapon and rate of fire positively affected heart rate activity (Figs 2 and 3). The MK-19 produced significantly higher RPkC and RPoTL scores than the M-139 (Friedman "analysis of variance," $p<0.05$). This suggests that the influence of the MK-19 on heart rate was both stronger and longer lasting. A Friedman "analysis of variance" failed to show statistically significant effects of rate of fire. However, when the low and high rates of fire were compared with a Wilcoxon signed-ranks test, the difference between the two rates was significant for both RPkC and RPoTL ($p<0.025$). Thus, a high rate of fire produced the largest heart rate increases, while there were no differences between the low and medium rates of fire.

There were eight players whose pop-up targets received hits on at least one of the recorded trials. For these eight players, Wilcoxon signed-ranks tests were used to compare "hit" with "no hit" trials on all four heart rate parameters. Figure 4 shows the average patterns for these parameters. Both RPkC and RPoTL were significantly higher on "hit" trials ($p<0.05$), indicating that a "hit" had a signal value beyond that of the basic trial's events. Interestingly, RPreTL was significantly lower ($p<0.035$) preceding "hit" trials; this may mean that lower arousal was more likely to lead to "careless" behavior during the trial.

Spearman rank-order correlation coefficients were computed to assess possible relationships between tracking performance scores and the various heart rate parameters (Appendix E, Table 1). Both RPreTL and RPoTL scores correlated significantly with performance scores, especially during M-139 trials. Higher RPreTL scores were associated with higher percent time and periscope up and tank kill scores, but only for M-139 trials. This may indicate that pre-trial arousal, or alertness, was more important for the relatively less noticeable M-139 fire. Higher RPoTL scores were associated with lower periscope performance scores. This applied equally to M-139 and MK-19 trials, and may reflect frustration or disappointment over having scored few tank kills.

The paper-and-pencil scales administered were generally not good predictors of performance or heart rate activity. The only significant correlations were between Trait Anxiety scores and (a) RPreTL scores on MK-19 trials ($r_s = 0.63$, $p<0.05$) and (b) RPreTA scores on MK-19 trials ($r_s = -0.55$, $p<0.05$). The average score on the Subjective Stress Scale during the trailer preparation phase was 6.1, corresponding to the scale item "indifferent." According to this, the average player did not perceive himself to be anxious or stressed at this point. When the players were later asked to recall how they felt during the first trial in the bunker, the average Subjective Stress Scale score was 6.1, identical to that obtained earlier in the trailer. Thus players did not perceive themselves to be stressed during bunker trials. However, when asked to estimate how they would have felt during the trial if they had been outside in the position of the pop-up

target, most of the players indicated "scared stiff" (the most extreme item). The average Subjective Stress Scale score under the latter condition was 10.4, corresponding to the scale item "agony." This gives a measure of the perceived protection afforded by the bunkers.

PHASE II - INDIRECT FIRE WEAPONS

Subjects

The subjects were eight enlisted men of the experimentation unit attached to CDEC. None of the eight had been a subject in Phase I. The players were organized in two teams of four men each. Although medical records were not examined, it is assumed that the players were normal and in good health. All subjects were briefed on the nature of the study, including possible adverse effects. Following the briefing, each volunteer read and signed a volunteer consent agreement (Appendix A).

Materials and Apparatus

No actual firing weapons were used in this phase. Rather, rounds were placed in position and detonated by signals from a pre-recorded master control tape. The types of rounds used were the 60 mm and 81 mm mortar rounds and the 105 mm and 155 mm howitzer rounds. Both actual and simulated (TNT) rounds were interspersed in random order.

The bunkers, periscopes, protective gear, and recording equipment all remained the same as in Phase I. However, 2½ ton trucks were used as targets driving along the up-range row of panels.

As in Phase I, the Trait Anxiety Inventory, the State Anxiety Inventory, and the Subjective Stress Scale were used to assess subjective state.

Method

A trial consisted of a series of explosions with a single size round positioned so that only one or two of the bunkers could see the explosions. The bunkers from which the explosions could be seen were designated the "receiving" bunkers.

Different sized rounds were positioned at varying distances from the bunkers chosen to equate, on the average, for sound pressure levels (not to exceed 130 db). The distances involved were: 20, 55, and 70 m for the 60 mm mortar; 30, 75, and 90 m for the 81 mm mortar; 35, 80, and 130 m for the 105 mm howitzer; and 70, 110, and 200 m for the 155 mm howitzer. Distance varied randomly within a trial. At the closest distance for each round, the dust from the explosions largely blocked the field of view. At the further distances, however, visual obstruction due to the explosions was restricted to the left or right side of the field of view. The number of rounds exploding during a trial was six for the 60 and 81 mm mortars, eight for the 105 mm howitzer, and ten for the 155 howitzer. Consecutive explosions within a trial were spaced at intervals of 10, 15, and 20 seconds according

to a random schedule. The length of a trial thus ranged from 100 sec to 170 sec, depending primarily on the number of explosions.

Trials occurred in blocks of two to four, with the time between trials varying from 5 to 50 min. A warning signal preceded each trial by approximately 60 sec and notified the players that the trial was about to begin. Players were seated at the periscope during each trial and remained inside the bunker between trials.

The game playing task remained the same as in Phase I. Players attempted to maximize tank kills and at the same time minimize the number of hits taken by the pop-up target.

As in Phase I, the paper-and-pencil scales were administered during the preparation phase at the start of the day's activities. On selected occasions, the Subjective Stress Scale and the State Anxiety Inventory were administered upon completion of a session.

Data Analysis

On each of the three days of data collection, tape recorded measures were obtained on four players. The same group was run on the second and third days, with one player replaced by a supernumerary on the third day. Due to a damaged microphone, one player's records on the first day were unusable. This left a total of eight players with usable data, three of which were run on two separate days. The schedule of trials recorded for each day is presented in Appendix F. As in Phase I, the uncontrolled sampling procedure yielded an unbalanced design for statistical purposes along with apparent cases of heterogeneity of variance. Thus, nonparametric statistics were used throughout, with data sets analyzed one factor at a time. The same statistical tests used with Phase I data were used here.

All data reduction and handling were conducted as in Phase I, Sample strip-chart visual displays of tape recordings are presented in Appendix G. The four basic heart rate parameters were computed in the same manner as in Phase I.

Results and Discussion of Results

The over-all increase in the heart rate seen in Phase I also attended bunker trials in Phase II. All four parameters were significantly greater than zero (Fig 5) as evaluated by sign test. Pretrial heart rates (RPreTL) were elevated an average of 19% over resting baseline rates ($p<0.001$; Fig 5A). The anticipation of the start of a trial was accompanied by significant transient acceleration (RPreTA) averaging 11% over all trials ($p<0.001$). The actual trial produced further increases in heart rate, as reflected in significant RPkC scores averaging 27% ($p<0.001$; Fig 5B). Finally, significant RPoTL scores ($p<0.013$; Fig 5C) showed heart rates were still elevated 1 min after the end of the trial. None of these four parameters showed any significant changes across trials.

In contrast with Phase I, weapon size did not appear to systematically affect RPkC (Fig 6). Size of weapon did appear to have a

systematic effect on RPoTL following non-receiving trials (Fig 7), although the over-all effect was not significant (Kruskal-Wallis test, $p = 0.20$). However, when only the 60 mm and 81 mm trials were compared, a Mann-Whitney U-test revealed a significant difference ($p = 0.029$). While inconclusive, the foregoing results tentatively suggest that visibility of the smaller explosions influenced the duration of elevations in heart rate.

There were only four players whose pop-up targets received hits, and only one such trial for each of these players. Because of the small number of cases, no formal statistical comparisons were done. However, among the limited data, it is worth noting that mean RPkC was twice as high on "hit" trials as it was on "no hit" trials. These results tend to substantiate the comparable figures from Phase I.

Spearman rank-order correlation coefficients were computed to assess possible relationships between periscope performance and the various heart rate parameters (Table 2). Different patterns can be seen for receiving and non-receiving trials. During receiving trials, RPeTL scores correlated significantly with performance scores. Higher RPeTL scores were associated with higher percent time periscope-up and tank-kill scores. This may indicate that greater alertness improved performance when explosions in the player's field of view made the tracking task more difficult. The high negative correlations between RPreTA and periscope performance may be an artifact due to the high negative correlation (-.87) between RPreTL and RPreTA. Alternatively, higher RPreTA scores may represent defensive responding which reduced performance via degraded perceptual functioning. During non-receiving trials, higher RPkC scores were associated with higher percent time periscope up and tank kill scores. Likewise, higher RPoTL scores were associated with higher frequencies of lowering the periscope, a pattern reminiscent of Phase I. While interpretation of these patterns is speculative, they do at least establish that the psychophysiological (and psychological?) factors contributing to task performance were different for receiving and non-receiving conditions.

As in Phase I, scores on the paper-and-pencil scales were not good predictors of periscope performance or heart rate activity. The only significant correlations were between State Anxiety and (a) RPkC scores (receiving trials, $r_s = .58$; non-receiving trials, $r_s = .62$) and (b) RPoTL scores following non-receiving trials ($r_s = .62$). The average score on the Subjective Stress Scale during the preparation phase in the trailer was 3.9, corresponding to the scale item "steady." When later asked to recall how they felt during the first trial in the bunker, the players' average Subjective Stress Scale rating was 4.1, nearly the same as that obtained earlier in the trailer. The same results occurred with State Anxiety: the average scores were 13.8 during trailer preparation and 13.0 during the first bunker trial. As in Phase I, the players did not perceive the bunker trials to be stressful. However, when asked to estimate how they would have felt during the first bunker trial if they had been outside in the position of the pop-up target, the average Subject Stress Scale score was 10.4. This value corresponds to the scale item "in agony." These results mirror those of Phase I.

PHASES I AND II COMPARED

Mann-Whitney U-tests were used to compare Phases I and II on heart rate parameters and paper-and-pencil scales. Averages of the various heart rate parameters for both phases are presented in Figure 8. Resting baseline heart rates were not significantly different, being almost identical for the two phases. However, RPreTL and RPreTA scores were significantly higher during Phase II, ($p<0.02$); and RPkC scores were 23% higher during Phase II, although the difference was not significant. Thus, the conditions of Phase II had a greater influence on heart rate activity than the conditions of Phase I. This occurred in spite of the fact that anxiety and stress scores tended to be lower in Phase II, although none of the differences were significant.

CONCLUSIONS

1. Heart rate proved to be a sensitive indicator; it reflected both anticipatory and responsive components.

2. The basic pattern of heart rate activity involved several phases: (a) mild elevation in baseline levels apparently brought about by being in the bunker and by facing an upcoming task; (b) transient elevation near the start of a trial, perhaps representing a preparatory or anticipatory response; (c) moderate sustained elevation during the trial in response to the explosions, the task requirements, or other trial events; (d) a gradual return toward pre-trial levels following the end of the trial. Whether these patterns represent stress, arousal, or some other dimension is unclear and deserves additional research.

3. Both rate of fire and size of direct fire weapons directly influenced heart rate activity.

4. Size of indirect fire weapons appeared to affect heart rate activity only marginally. This may have been due to the larger rounds being placed further from the bunkers. Visibility of the exploding rounds may have interacted with size. Several suggestive trends warrant further research.

5. Hits received by the pop-up target had a substantial accelerating effect on heart rate.

6. Various heart rate parameters correlated significantly with periscope performance and thus offer potential for predicting performance under stressful conditions. Establishment of predictive relationships may lead to the ability to reduce stress effects or otherwise modify inappropriate responses as well as to pretest soldiers for critical assignments.

7. The pattern of correlations between heart rate parameters and performance varied between different conditions. This suggests that psychophysiological correlates of performance may depend on specific task conditions. Much further research would be required to document this.

8. Perceived anxiety and stress scales may have been accurate in gauging the current state of the individual, but they were not good predictors of performance or heart rate activity.

9. Conditions of the indirect-fire phase had a greater influence on heart rate activity than those of the direct-fire phase.

10. Further research is needed to test the utility of other psychophysiological measures in the field studies of stress.

RECOMMENDATIONS

The weapons effects to which the players were exposed during the SUPEX exercise may be reproduced accurately in the laboratory. Similarly, target acquisition and tracking tasks may be simulated in a laboratory setting. It is recommended that the SUPEX problem be studied in the laboratory where precise manipulation of the parameters of the different stimuli would be possible, and where more comprehensive physiological monitoring procedures may be employed. The resulting data will provide valuable information concerning the biomedical and behavioral consequences of exposure to non-lethal blast effects and may lead to the formulation of new hypotheses which could be tested under field conditions.

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APPENDICES

APPENDIX A
VOLUNTEER AGREEMENT

I, ______________________, having attained my eighteenth (18th) birthday and otherwise having full capacity to consent, do hereby volunteer to participate in a research study of psychological correlates of field performance, being conducted by Letterman Army Institute of Research in conjunction with the SUPEX project of the Combat Developments Experimentation Command.

The implications of my voluntary participation; the nature, duration and purpose; the methods and means by which it is to be conducted; and the inconveniences and hazards which may reasonably be expected have been explained to me by ______________________, and are set forth in the attachment to this Agreement, which I have initialed. I have been given an opportunity to ask questions concerning this investigational study, and any such questions have been answered to my full and complete satisfaction.

I understand that I may at any time during the course of this study revoke my consent, and withdraw from the study without prejudice.

______________________ __________
Signature Date

I was present during the explanation referred to above, as well as the volunteer's opportunity for questions, and hereby witness his signature.

______________________ __________
Witness' Signature Date

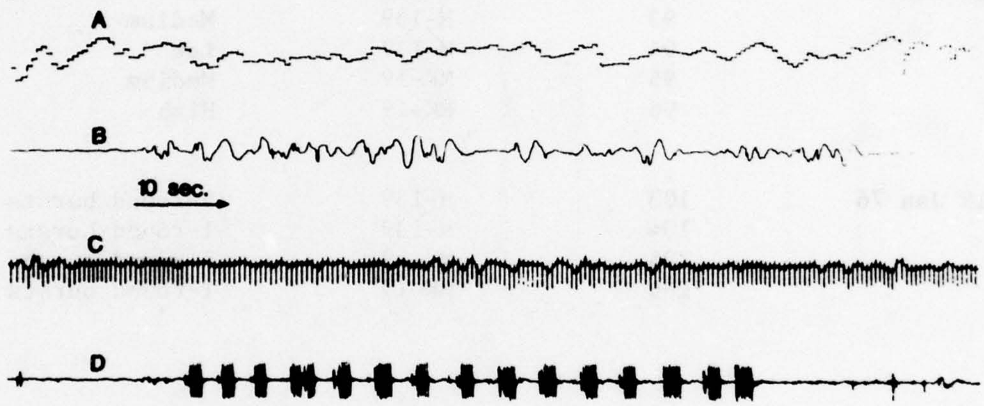
APPENDIX B
SCHEDULE OF TRIALS RECORDED DURING PHASE I

Date	Trial #	Weapon	Rate of Fire
13 Jan 76	73	M-60	High
	74	M-139	High
	75	M-139	Medium
	76	MK-19	Medium
	78	M-139	Low
14 Jan 76	92	MK-19	Low
	93	M-139	Medium
	94	M-139	Low
	95	MK-19	Medium
	96	MK-19	High
15 Jan 76	103	M-139	5-round bursts
	104	M-139	1-round bursts
	105	MK-19	5-round bursts
	106	MK-19	1-round bursts

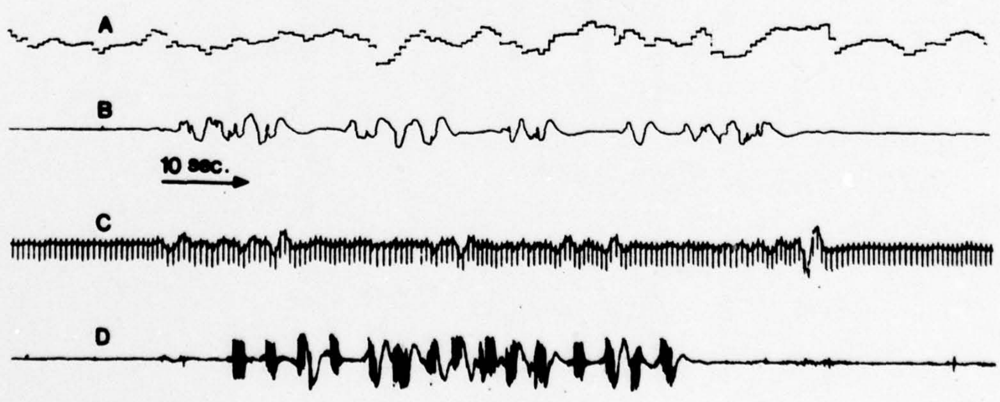
APPENDIX C

SAMPLE DISPLAYS OF RECORDINGS OBTAINED
IN PHASE I

Sample recordings were obtained during exposure to high explosive rounds delivered by a M-139, 20 mm cannon, or MK-19, 40 mm grenade launcher. A=Cardiotachometer output, B=electromyogram, C=electrocardiogram, D=sound track. Conspicuous movement artifacts are evident in the electromyogram during the period of weapons firing.

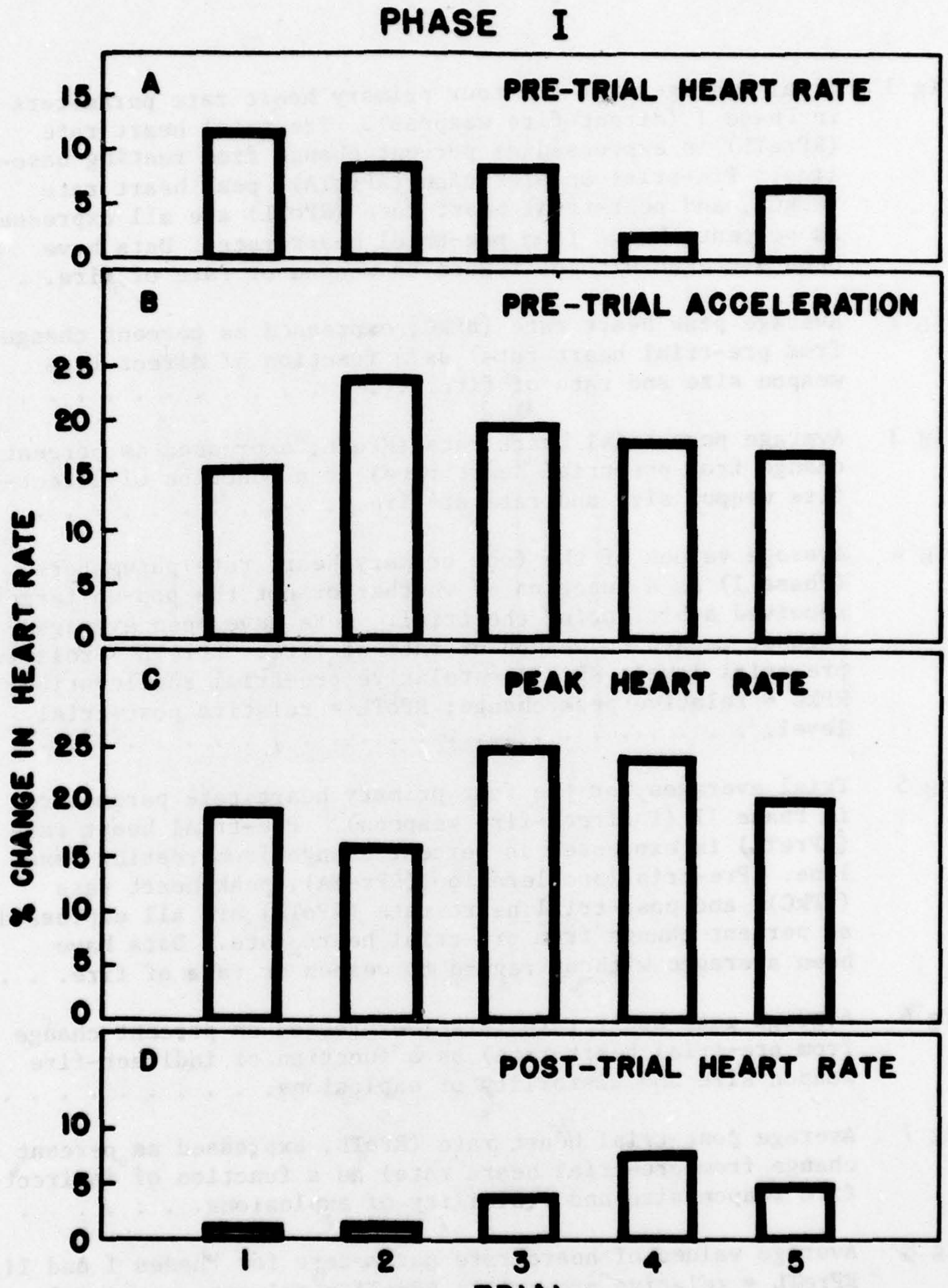


M-139



MK-19

APPENDIX D
FIGURE CAPTIONS



PHASE I
A
PRE-TRIAL HEART RATE
B
PRE-TRIAL ACCELERATION
C
PEAK HEART RATE
D
POST-TRIAL HEART RATE
% CHANGE IN HEART RATE
TRIAL
1
2
3
4
5

Figure 1

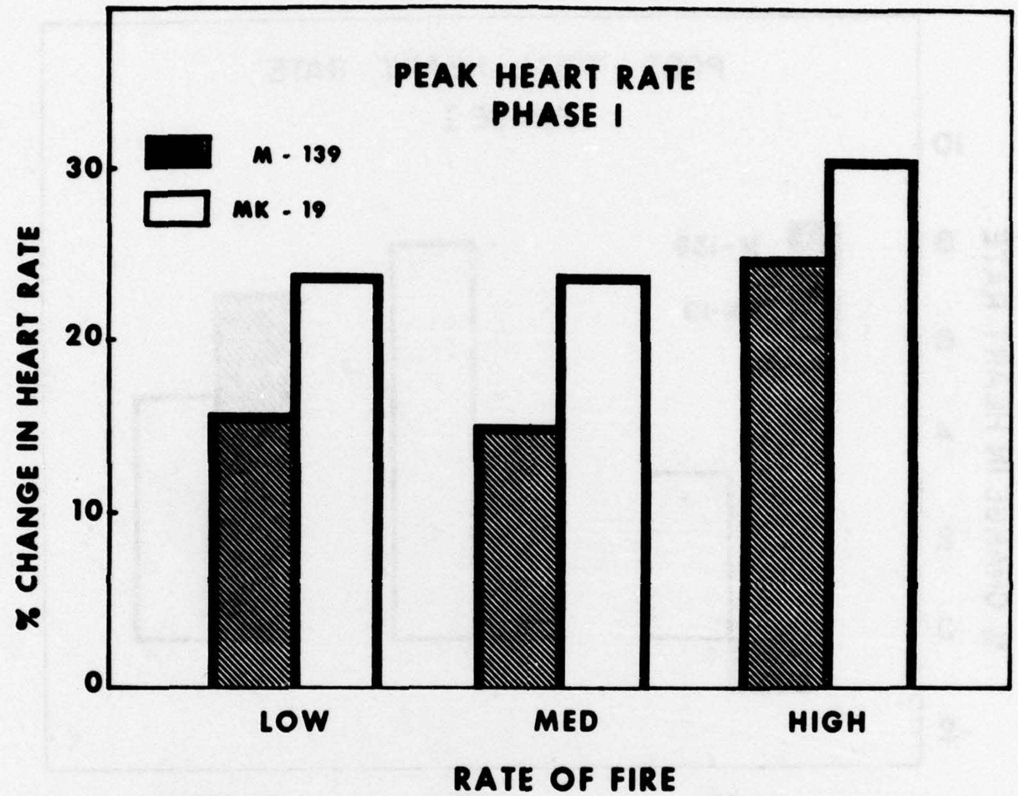

PEAK HEART RATE
PHASE I
M - 139
MK - 19
% CHANGE IN HEART RATE
30
20
10
0
LOW
MED
HIGH
RATE OF FIRE

Figure 2

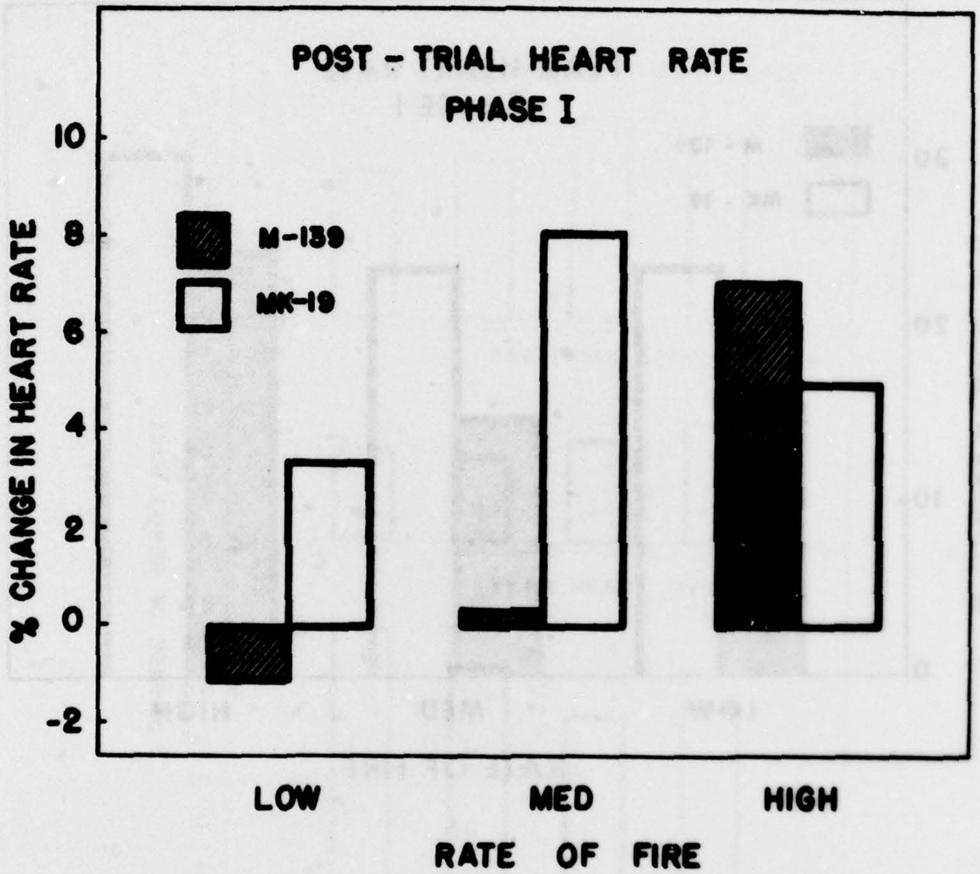

POST - TRIAL HEART RATE
PHASE I
M-139
MK-19
% CHANGE IN HEART RATE
10
8
6
4
2
0
-2
LOW
MED
HIGH
RATE OF FIRE

Figure 3

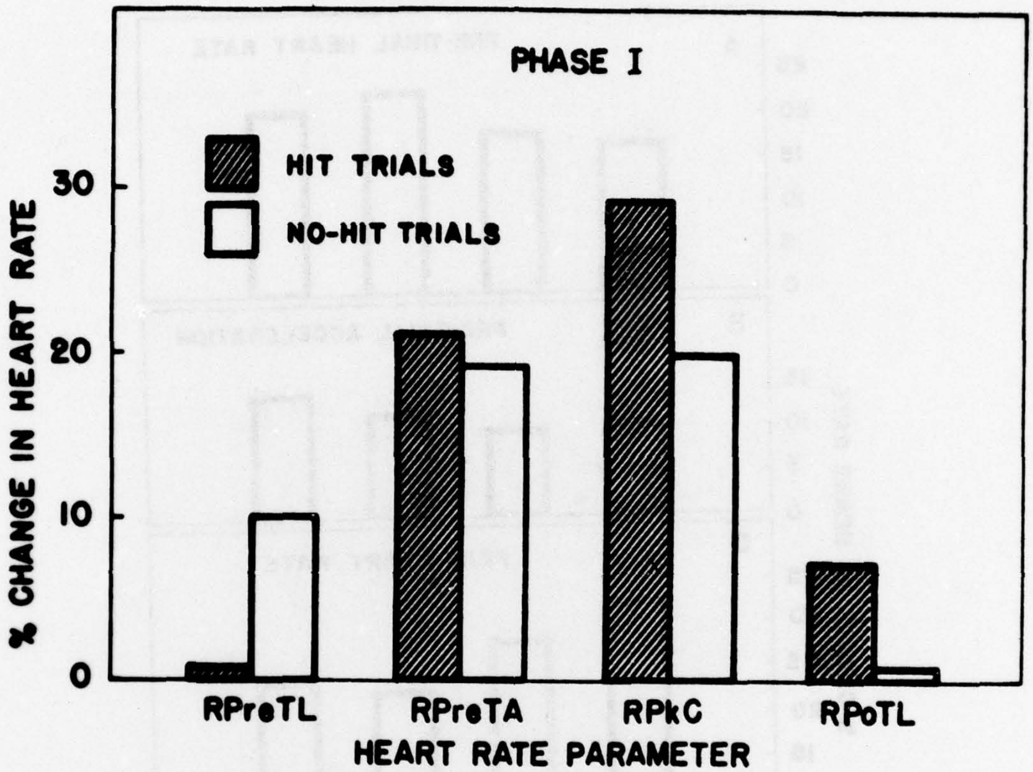

PHASE I
HIT TRIALS
NO-HIT TRIALS
% CHANGE IN HEART RATE
30
20
10
0
RPreTL
RPreTA
RPkC
RPoTL
HEART RATE PARAMETER

Figure 4

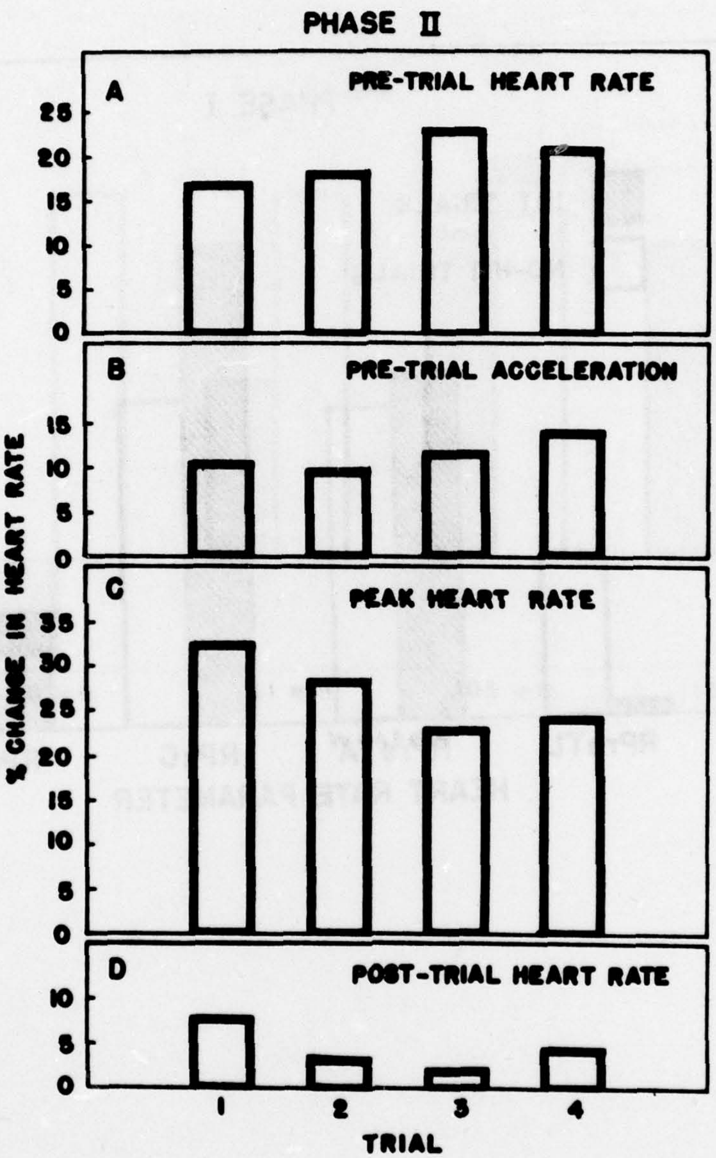

PHASE II
A
PRE-TRIAL HEART RATE
B
PRE-TRIAL ACCELERATION
C
PEAK HEART RATE
D
POST-TRIAL HEART RATE
% CHANGE IN HEART RATE
TRIAL
1
2
3
4

Figure 5

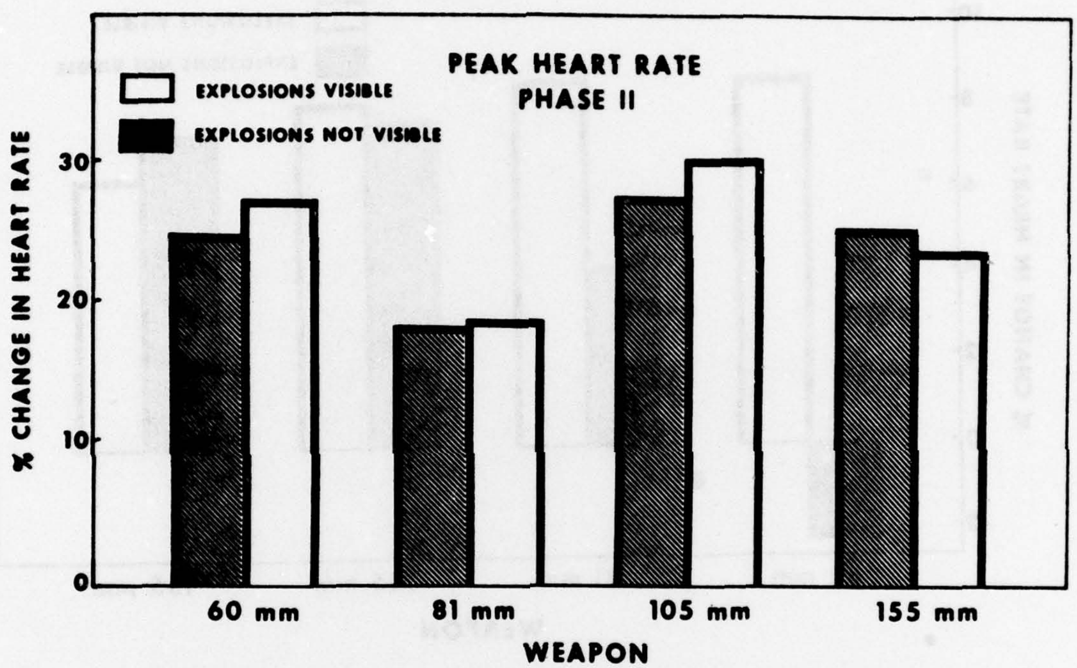
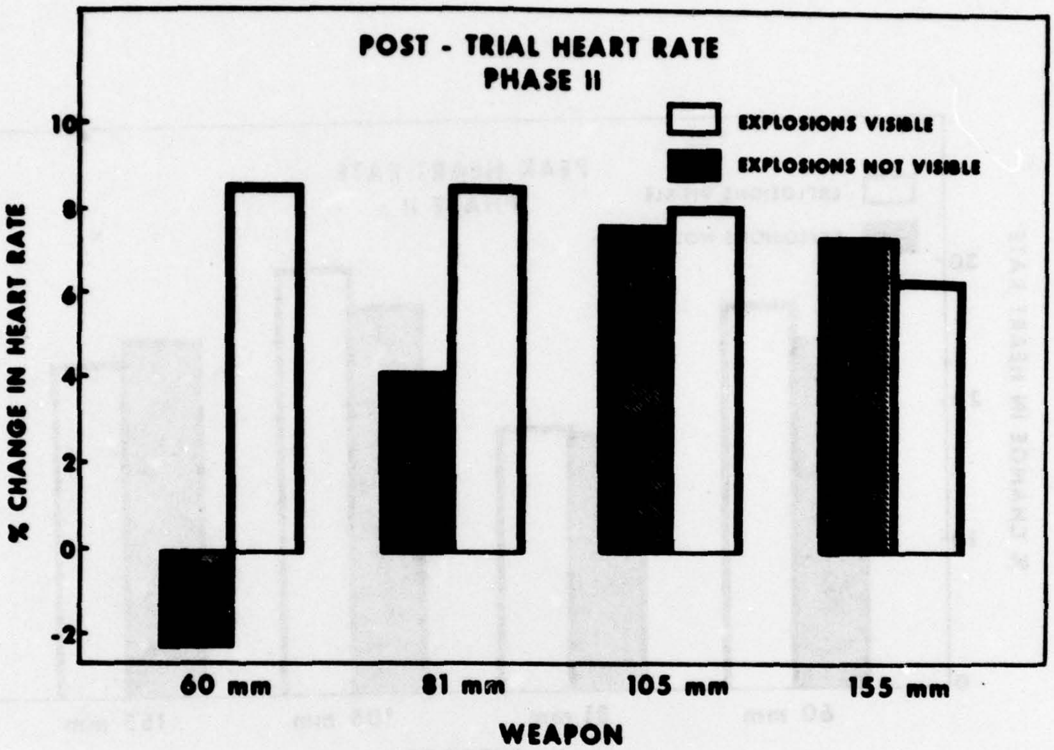

PEAK HEART RATE
PHASE II
EXPLOSIONS VISIBLE
EXPLOSIONS NOT VISIBLE
% CHANGE IN HEART RATE
30
20
10
0
60 mm
81 mm
105 mm
155 mm
WEAPON

Figure 6



POST - TRIAL HEART RATE
PHASE II
EXPLOSIONS VISIBLE
EXPLOSIONS NOT VISIBLE
% CHANGE IN HEART RATE
10
8
6
4
2
0
-2
60 mm
81 mm
105 mm
155 mm
WEAPON

Figure 7

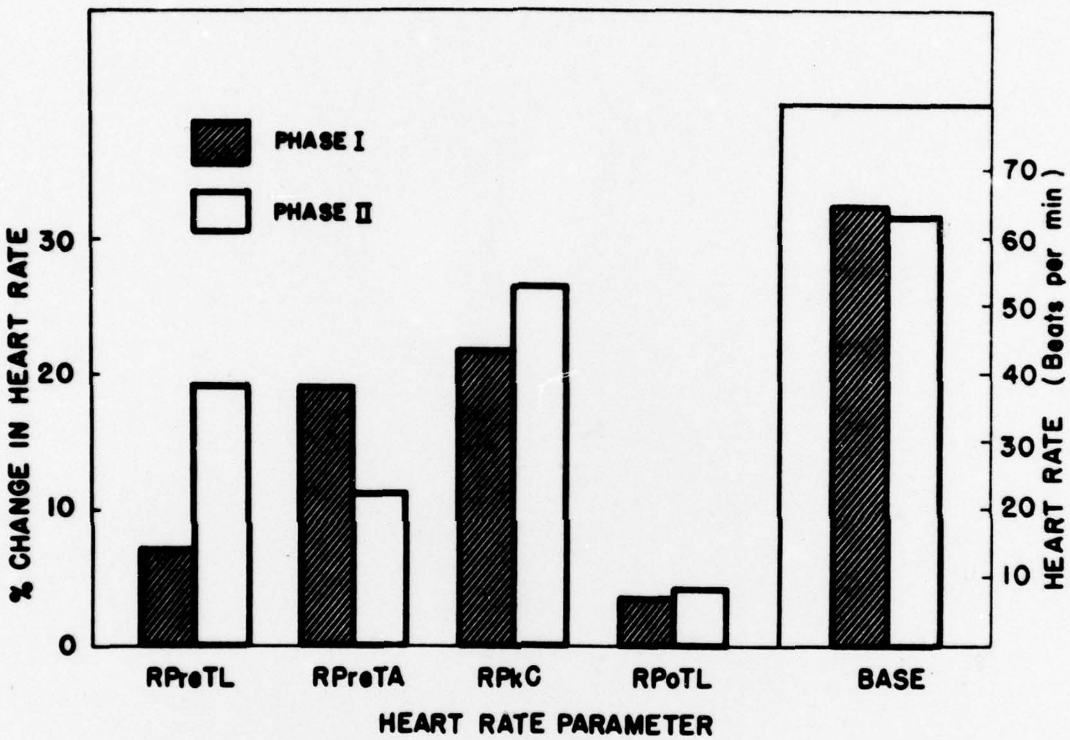

PHASE I
PHASE II
% CHANGE IN HEART RATE
0
10
20
30
HEART RATE (Beats per min)
10
20
30
40
50
60
70
RPreTL
RPreTA
RPkC
RPoTL
BASE
HEART RATE PARAMETER

Figure 8

APPENDIX E

TABLES 1 AND 2

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TABLE 1
SPEARMAN RANK-ORDER CORRELATION COEFFICIENTS COMPUTED BETWEEN HEART RATE PARAMETERS AND PERISCOPE PERFORMANCE MEASURES, PHASE I

	Relative Pre-Trial Level	Relative Pre-Trial Acceleration	Relative Peak Change	Relative Post-Trial Level
M-139 Trials				
% Time Up	.72	-.40	-.15	-.53
# Tank Kills	.55	-.35	-.22	-.55
# Times Periscope Down	-.60	.33	.03	.60
MK-19 Trials				
% Time Up	.18	-.16	.25	-.58
# Tank Kills	.14	-.30	-.01	-.41
# Times Peri-Scope Down	.11	-.08	-.09	.53

Note: With N = 11, a value of .54 or larger is significant at the 0.05 level.

TABLE 2
SPEARMAN RANK-ORDER CORRELATION COEFFICIENTS
COMPUTED BETWEEN HEART RATE PARAMETERS AND
PERISCOPE PERFORMANCE MEASURES, PHASE II

	Relative Pre-Trial Level	Relative Pre-Trial Acceleration	Relative Peak Change	Relative Post-Trial Level
Receiving Fire				
% Time Up	.75	-.88	.04	-.36
# Tank Kills	.74	-.73	.12	-.12
# Times Periscope Down	-.04	-.05	.13	-.15
Not Receiving Fire				
% Time Up	-.11	.04	.64	.11
# Tank Kills	-.07	.29	.68	.39
# Times Periscope Down	.35	.40	.42	.65

Note: With N = 8, a value of .64 or larger is significant at the .05 level.

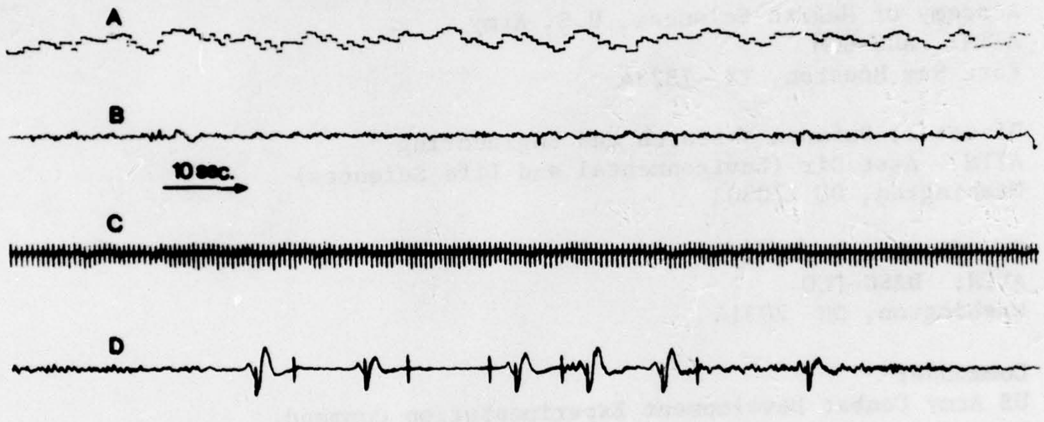
APPENDIX F
SCHEDULE OF TRIALS RECORDED IN PHASE II

Date	Trial #	Weapon
18 Feb 76	511-512	105 mm
	513-514	155 mm
19 Feb 76	517-520	60 mm
20 Feb 76	605-608	81 mm
	609-610	105 mm

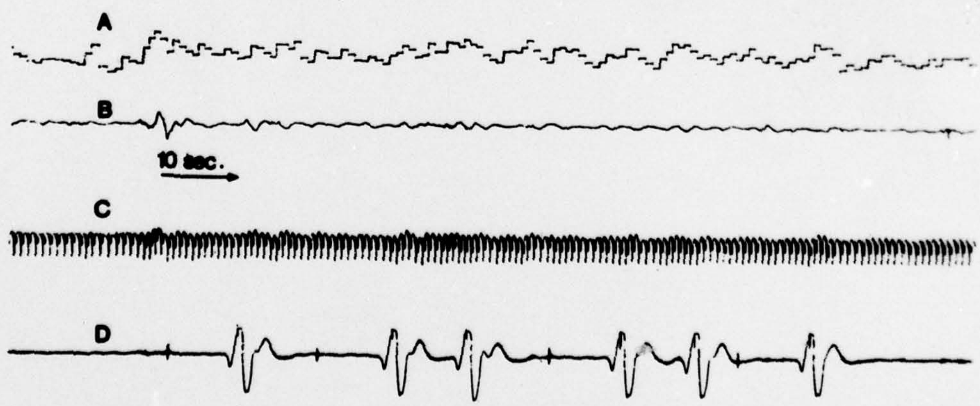
APPENDIX G

SAMPLE DISPLAYS OF RECORDINGS OBTAINED IN PHASE II

Sample recordings were obtained during detonation of 60 mm and 81 mm mortar projectiles. A=cardiotachometer record obtained during playback. B=electromyogram, C=electrocardiogram, D=sound track.



60 mm. MORTAR



81 mm. MORTAR

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